



# ESNI CONFERENCE

**20 september 2023**

*Recovering nutrients from aquaculture industry by-products*

**Atlantic case: Fractionation of fish-farming by-products by twin-screw extrusion to produce biobased fertilisers**

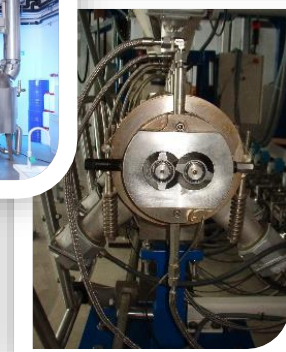
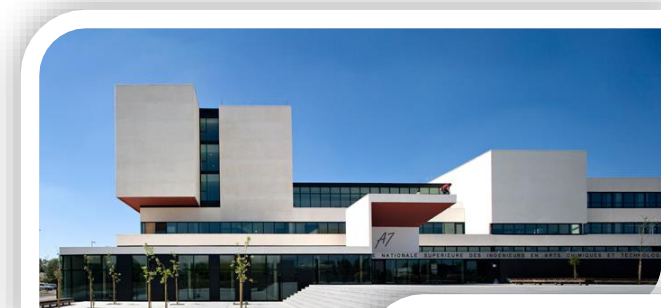
*(Clement CHASTRETTE - CATAR)*

# Presentation of CATAR



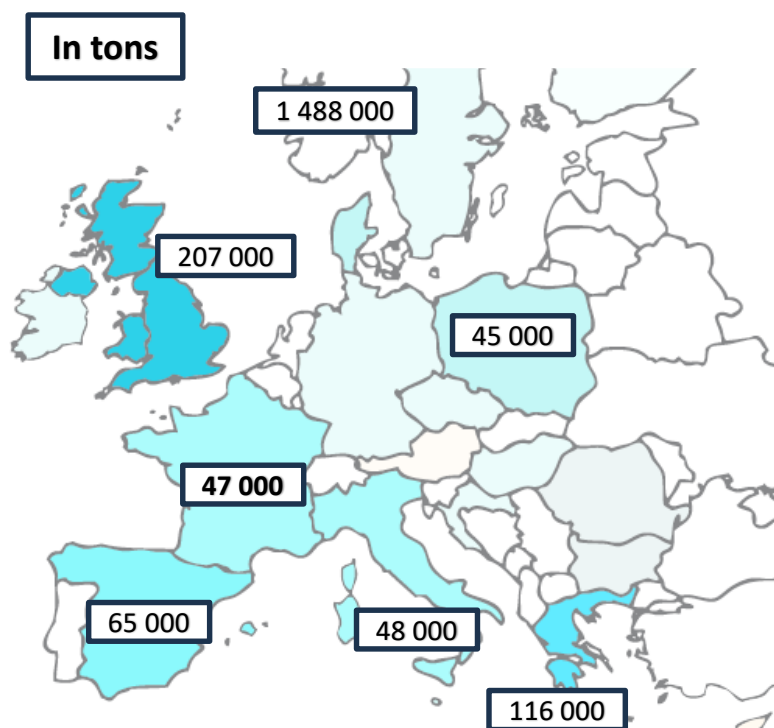
[www.catar.critt.net](http://www.catar.critt.net)

- ❖ **Located:** Toulouse (FRANCE)
- ❖ **RTO** since 1991
- ❖ Labeled « **Technological Resource Center** (CRT) » by the French Ministry of Research
- ❖ **Missions:** Innovation's support through R&D&I and technology transfer
- ❖ **Expert in the application and treatment of bioresources** in partnership with academic, agricultural and industrial sectors
- ❖ **Expertise:**
  - ❖ **Biorefinery**, specifically extraction and fractionation of plant and animal raw materials
  - ❖ **Synthesis** and hemisynthesis of agromolecules
  - ❖ **Physico-chemical and sensory characterization** of fine molecules and biomolecules
  - ❖ Characterization and production of **industrial-size samples** (scale-up)
- ❖ **Expertise related to Sea2Land:** Fractionation by twin screw extrusion



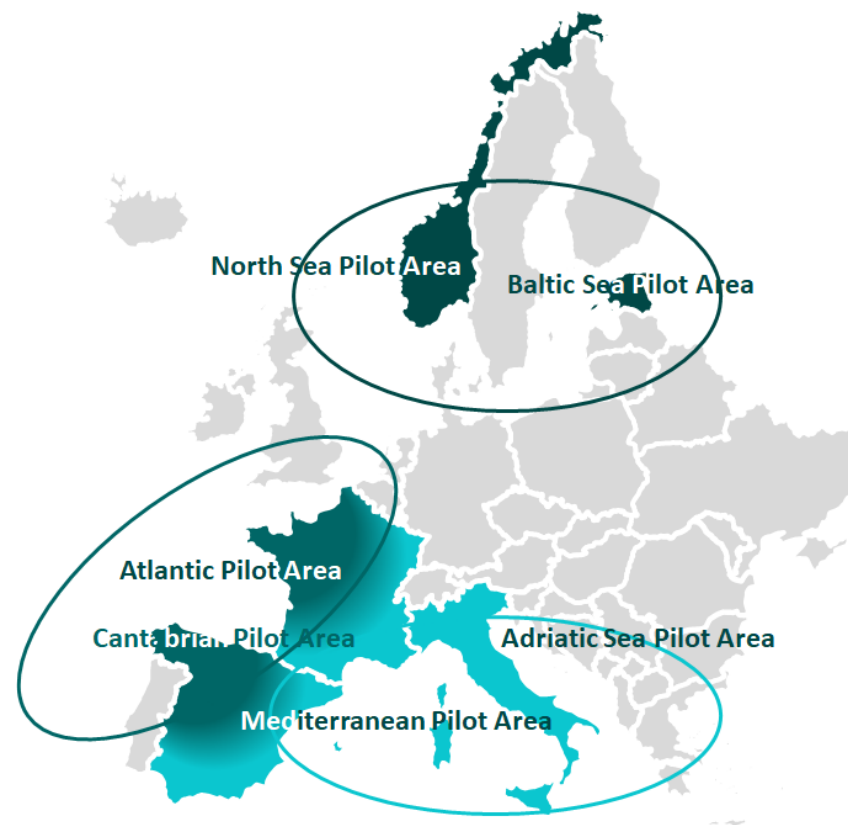
# SEA2LAND: Aquaculture Mapping

## Aquaculture's production in 2020



[GRAPH'AGRI 2022: <https://www.agreste.agriculture.gouv.fr/>]

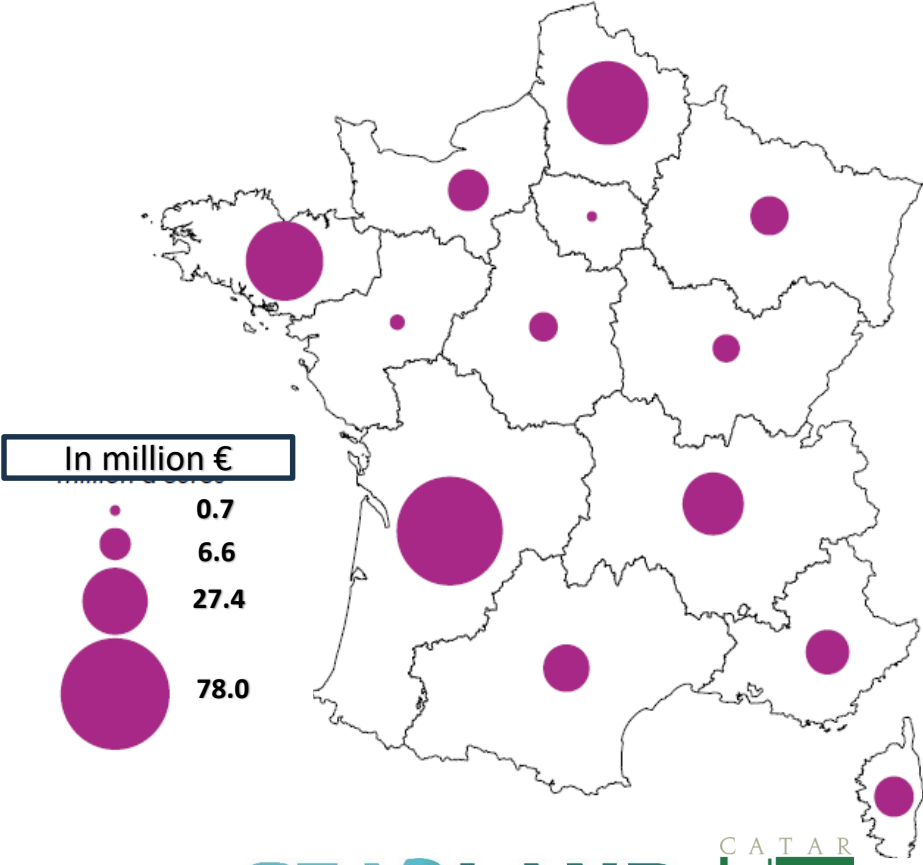
## Sea2Land: studied areas



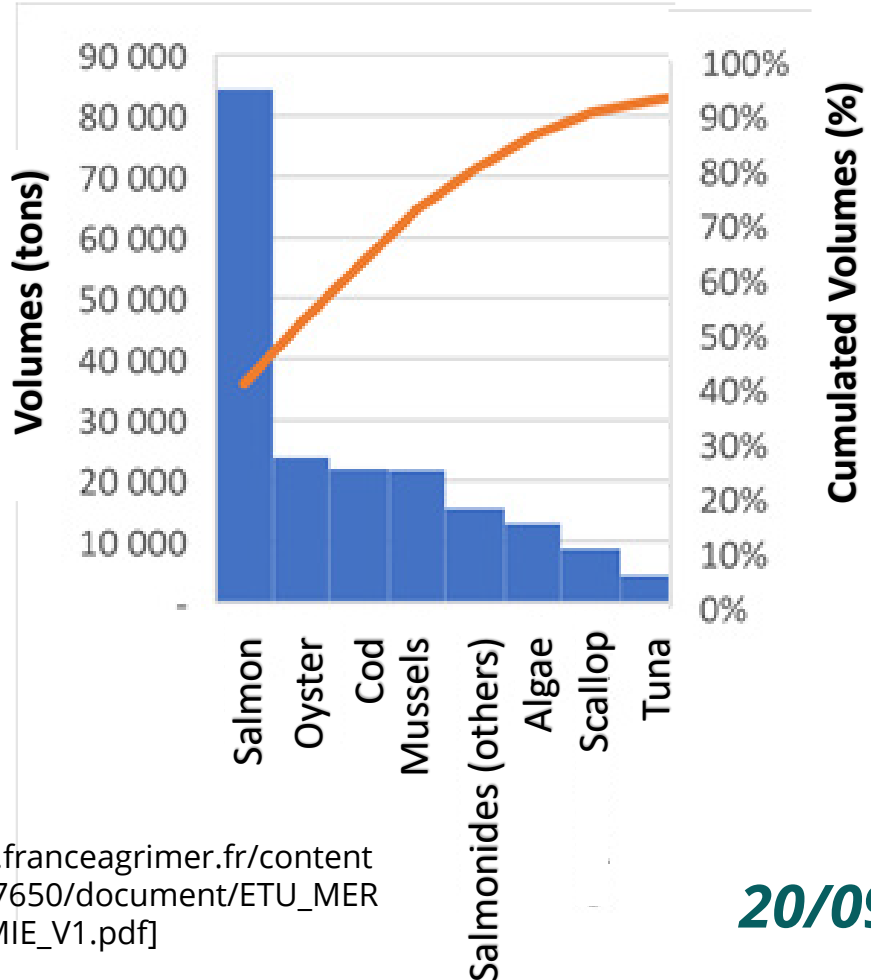


# SEA2LAND: Aquaculture Mapping

French fish-farming sales in 2020



French fish-farming volumes in by-products (2018)

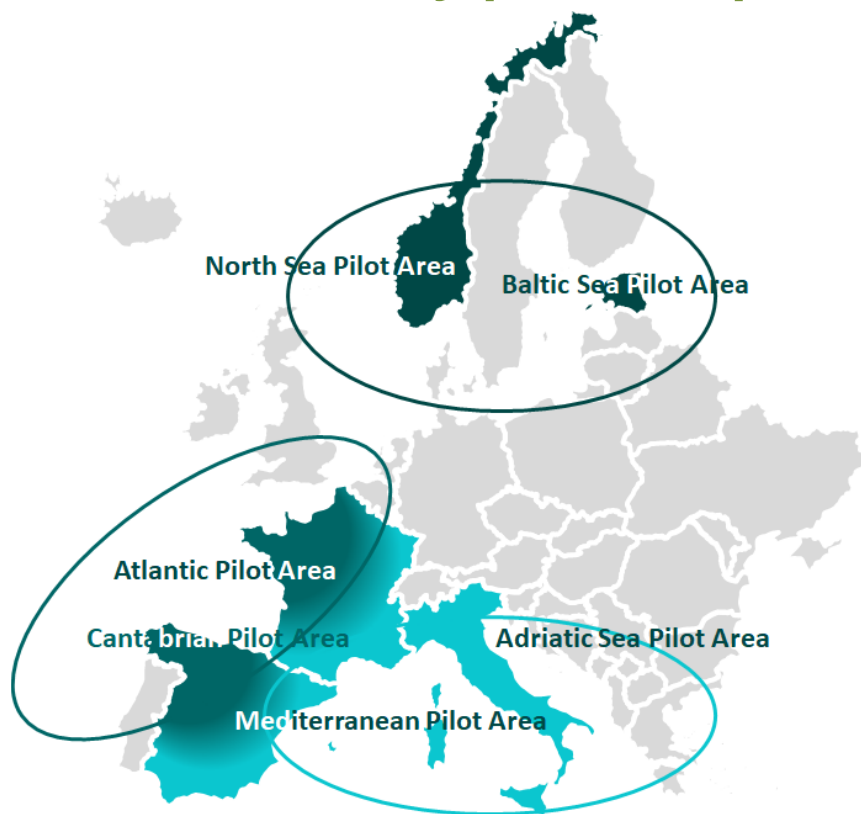


[[https://www.franceagrimer.fr/content/download/67650/document/ETU\\_MER\\_BIOECONOMIE\\_V1.pdf](https://www.franceagrimer.fr/content/download/67650/document/ETU_MER_BIOECONOMIE_V1.pdf)]

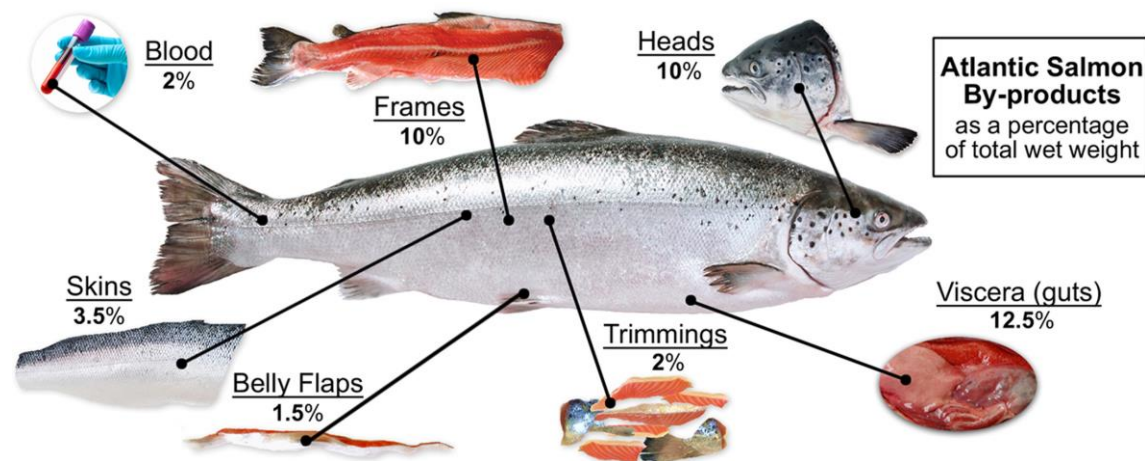
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# SEA2LAND: Aquaculture Mapping

## Assessment of by-products potential in the Atlantic area

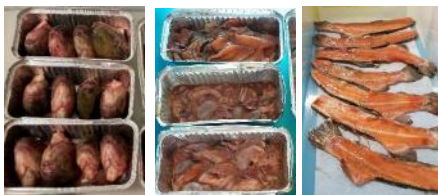
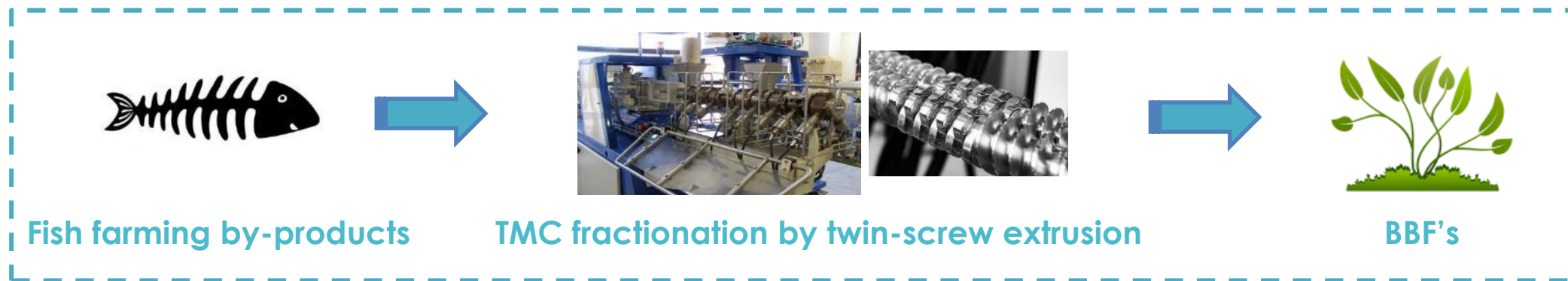


Atlantic area = 15 000 tons / year of fish-byproducts



[Marine Policy , 90(2018), 115-124]

# SEA2LAND: The Atlantic case



**Supplier:** Pisciculture Ispeguy

**By-products:** Heads, frames & viscera from Steelhead trout

## Thermo-mechano-chemical (TMC)

**fractionation:** Continuous production by the *in situ* solid/liquid separation by extrusion of:

- a BBF as the solid fraction of the process
- and an oily fraction as the liquid fraction.
- Optimization of the operating parameters to:
  - Maximize the yield in N, P, K in the solid fraction
  - Reach an improved selectivity between lipids and proteins
- Enzymatic hydrolysis in the twin-screw extruder

## Products:

- BBF1: Fertilizer
- BBF2: Biostimulant

# SEA2LAND: The Atlantic case

Partner: CAPA

Research and  
identification of potential  
aquaculture partners in the  
Atlantic zone



List of potential industrial  
suppliers of by-products



Partner: CATAR



Establishing a partnership  
between the by-product  
supplier and CATAR



Pisciculture Ipeguy  
Saint Etienne de Baigorri



**IZPEGI**  
Arraina · Truite  
— Baigorri —



# SEA2LAND: The Atlantic case

## Characterization of raw materials

### Rainbow trout by-products (*Oncorhynchus mykiss*)



**IZPEGI**  
Arraina · Truite  
— Baigorri —



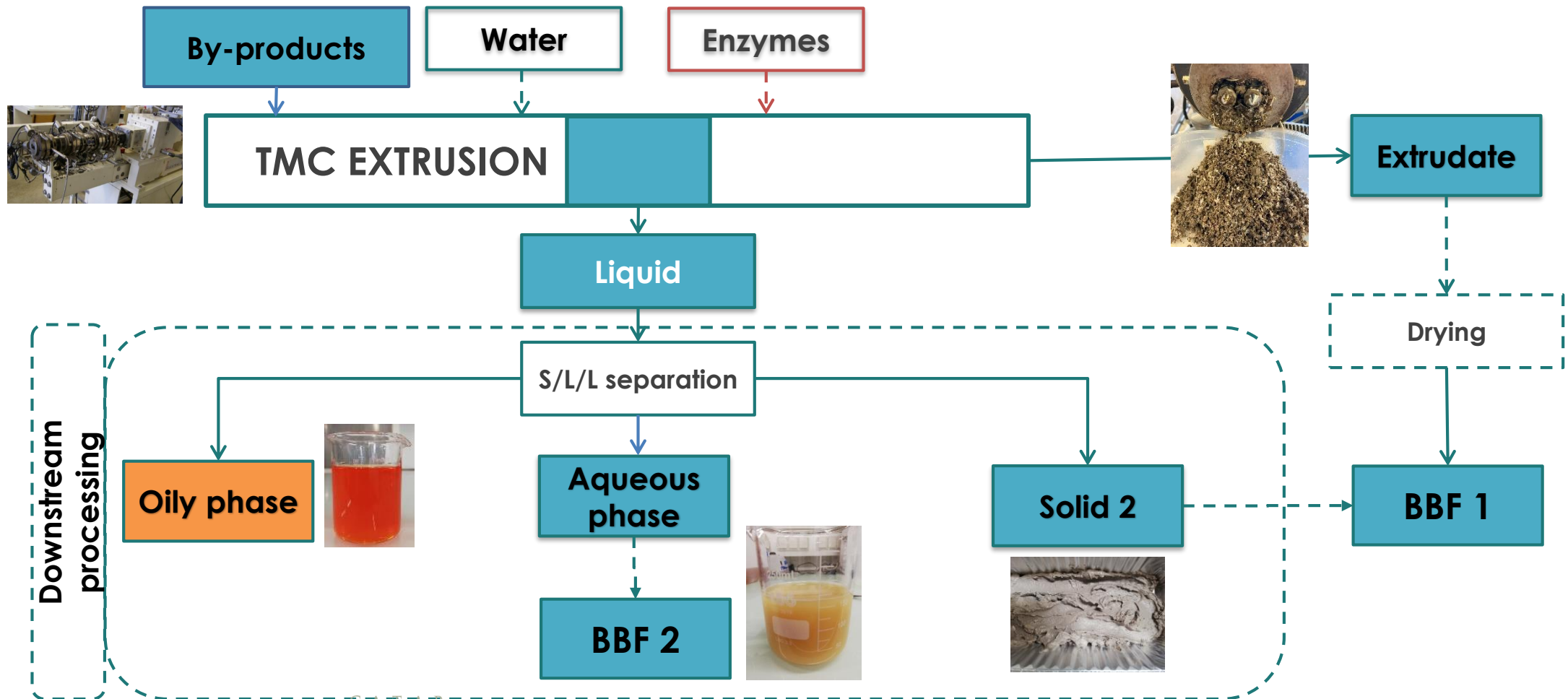
|          | Unit   | Heads      | Frames     | Mix<br>Heads/Frames |
|----------|--------|------------|------------|---------------------|
| DM       | (%)    | 35.0 ± 1.0 | 35.0 ± 1.0 | 35.0 ± 1.0          |
| Ashes    | (%/DM) | 11.8 ± 1.6 | 10.7 ± 1.5 | 12.4 ± 0.1          |
| Proteins | (%/DM) | 37.9 ± 2.0 | 38.4 ± 2.4 | 42.7 ± 3.4          |
| Lipids   | (%/DM) | 42.5 ± 3.8 | 46.5 ± 5.6 | 44.4 ± 1.3          |

|    | Unit   | Heads       | Frames      |
|----|--------|-------------|-------------|
| TN | (%/DM) | 6.8 ± 0.1   | 6.5 ± 0.1   |
| TP | (%/DM) | 1.4 ± 0.4   | 1.9 ± 0.1   |
| TK | (%/DM) | 0.54 ± 0.06 | 0.62 ± 0.01 |



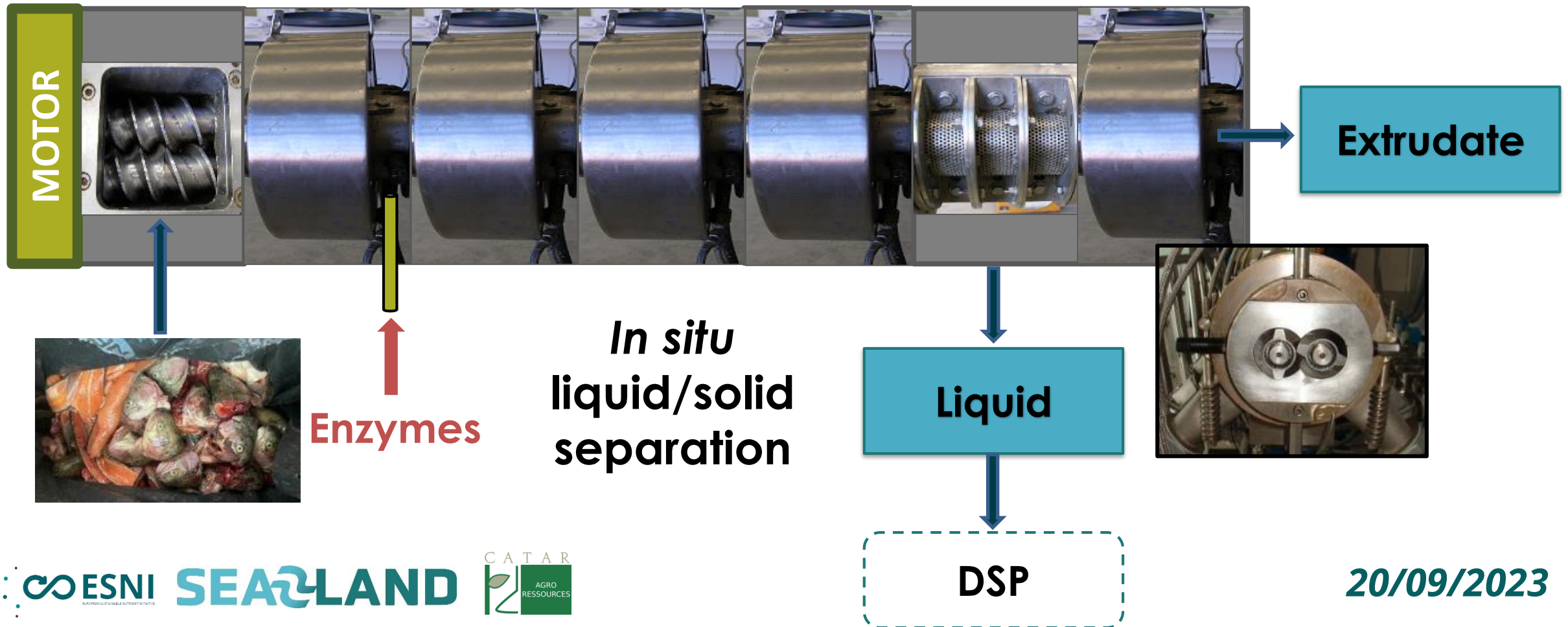
# SEA2LAND: The Atlantic case

## Process flowchart



# SEA2LAND: The Atlantic case

## TMC fractionation by twin-screw extrusion



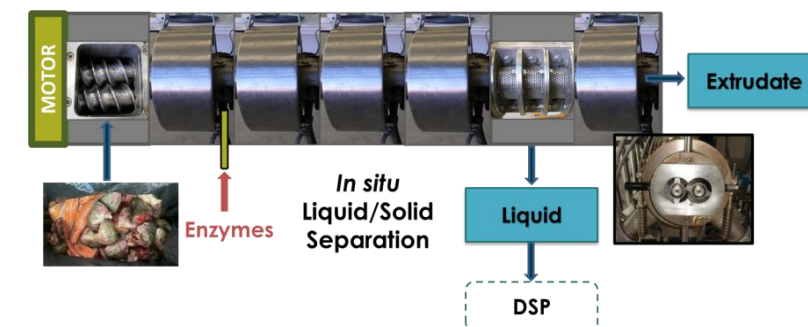
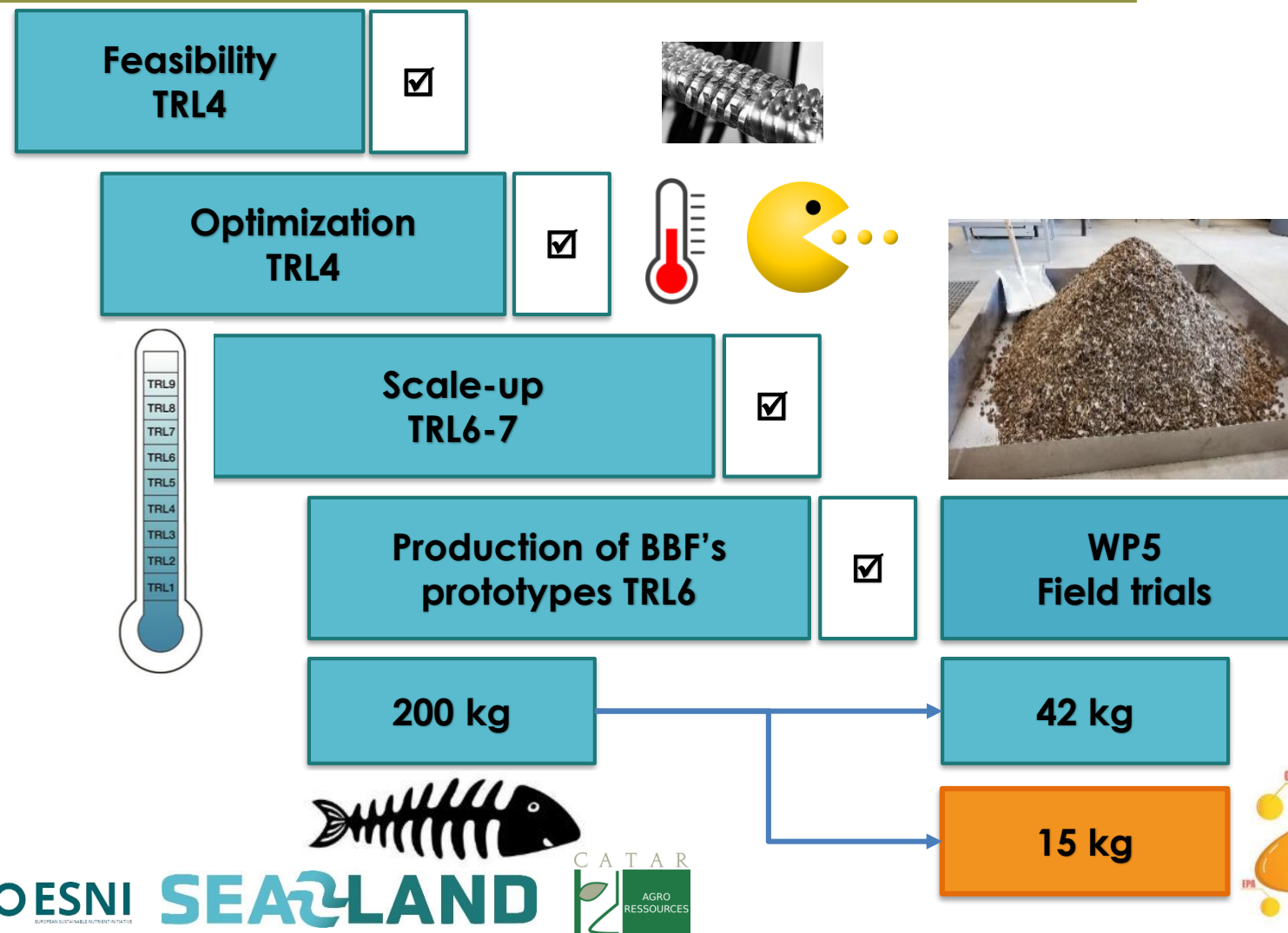
# SEA2LAND: The Atlantic case

## TMC fractionation by twin-screw extrusion





# SEA2LAND: The Atlantic case



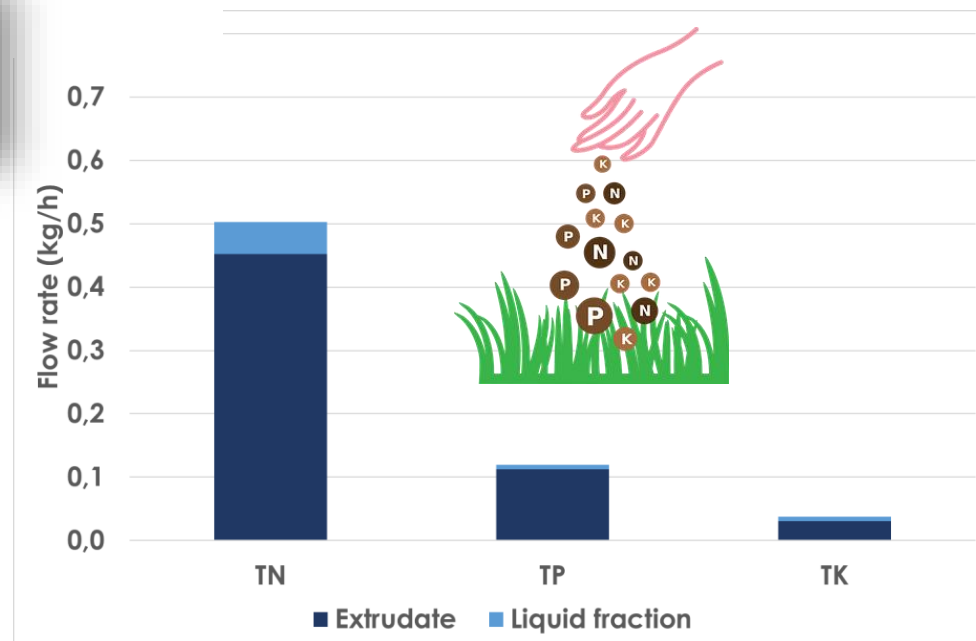
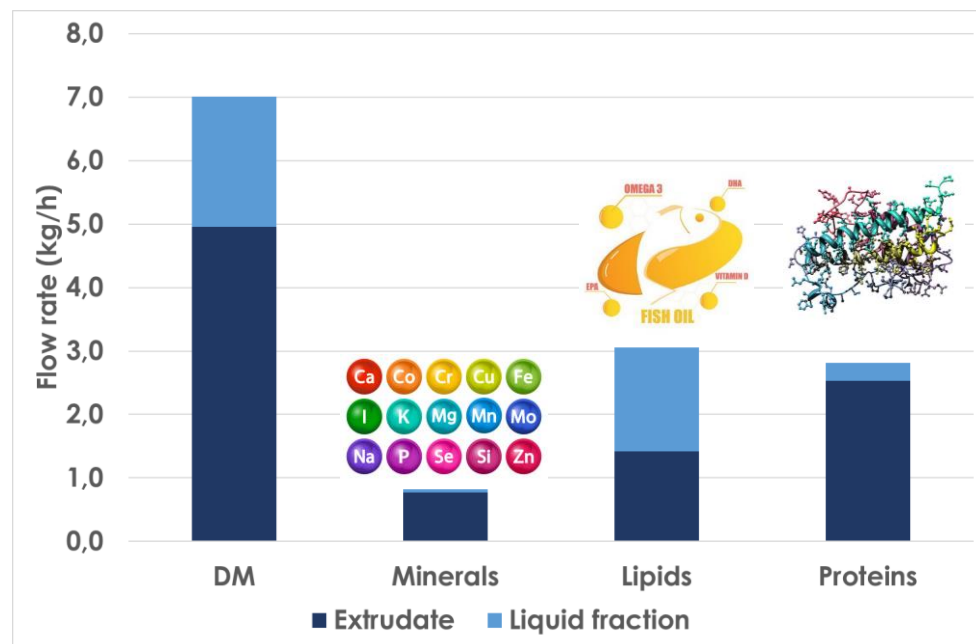
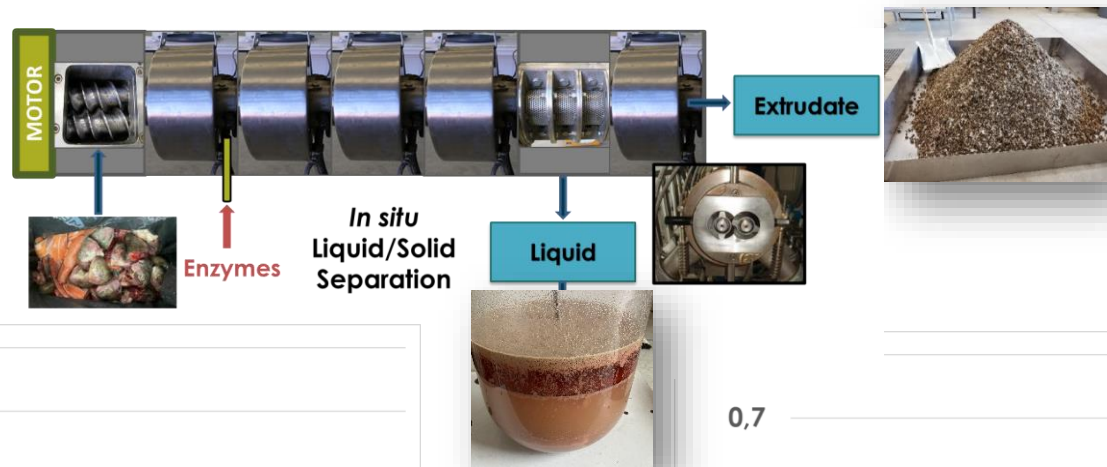
|            | Unit    | BBF5       |
|------------|---------|------------|
| TS (or DM) | %       | 96.2 ± 0.1 |
| Ashes      | %/DM    | 14.8 ± 0.7 |
| TN         | %/DM    | 9.1 ± 0.1  |
| TP         | g/kg DM | 31.5 ± 0.7 |
| TK         | g/kg DM | 6.2 ± 0.1  |
| Lipids     | %/DM    | 28.0 ± 0.3 |





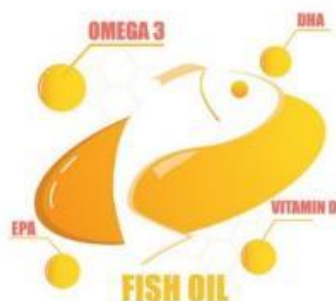
# SEA2LAND: The Atlantic case

## TMC fractionation efficiency



# SEA2LAND: The Atlantic case

## Oily phase analysis



| $\beta$ -carotene<br>equivalent | Astaxanthin<br>equivalent |
|---------------------------------|---------------------------|
| 14 mg/kg                        | 11 mg/kg                  |

|                 |                 |                                       | Heads       | Frames      | Oily phase  |
|-----------------|-----------------|---------------------------------------|-------------|-------------|-------------|
| Saturated       | C14:0           | Myristate                             | 1,5         | 1,6         | 1,9         |
|                 | <b>C16:0</b>    | <b>Palmitate</b>                      | <b>10,3</b> | <b>10,3</b> | <b>10,6</b> |
|                 | C18:0           | Stearate                              | 2,7         | 2,6         | 2,8         |
|                 | C20:0           | Arachidate                            | 0,3         | 0,3         | n.d.        |
|                 | C22:0           | Behenate                              | 1,3         | 1,5         | n.d.        |
|                 | Total (%)       |                                       | 16,2        | 16,4        | 15,2        |
| Monoinsaturated | C16:1n7c        | Palmitoleate                          | 1,9         | 2,0         | 2,5         |
|                 | <b>C18:1n9c</b> | <b>Oleate</b>                         | <b>48,1</b> | <b>47,3</b> | <b>48,0</b> |
|                 | C18:1n-7c       | Vaccenate                             | 3,2         | 3,2         | 3,2         |
|                 | C20:1n9c        | Gondoate                              | 1,1         | 1,2         | 2,4         |
|                 | C20:1n7         | Gadoleate                             | 1,1         | 1,1         | 0,9         |
|                 | C22:1n9         | Erucate                               | 0,0         | 0,0         | 0,3         |
|                 | Total (%)       |                                       | 55,5        | 54,8        | 54,8        |
| Polyinsaturated | <b>C18:2n6c</b> | <b>Linoleate</b>                      | <b>17,3</b> | <b>17,6</b> | <b>17,8</b> |
|                 | <b>C18:3n3</b>  | <b><math>\alpha</math> Linolenate</b> | <b>4,5</b>  | <b>4,6</b>  | <b>4,6</b>  |
|                 | C20:2n-6        | Eicosadienoate                        | 0,7         | 0,8         | n.d.        |
|                 | C20:3n-6        | Dihomo-gamma-linolenate               | 0,3         | 0,3         | n.d.        |
|                 | C20:4n-6        | Arachidonate                          | 0,6         | 0,7         | n.d.        |
|                 | <b>C20:5n-3</b> | <b>EPA</b>                            | <b>1,2</b>  | <b>1,2</b>  | <b>1,6</b>  |
|                 | <b>C22:6n-3</b> | <b>DHA</b>                            | <b>3,5</b>  | <b>3,5</b>  | <b>3,5</b>  |
|                 | Total (%)       |                                       | 28,3        | 28,8        | 27,5        |

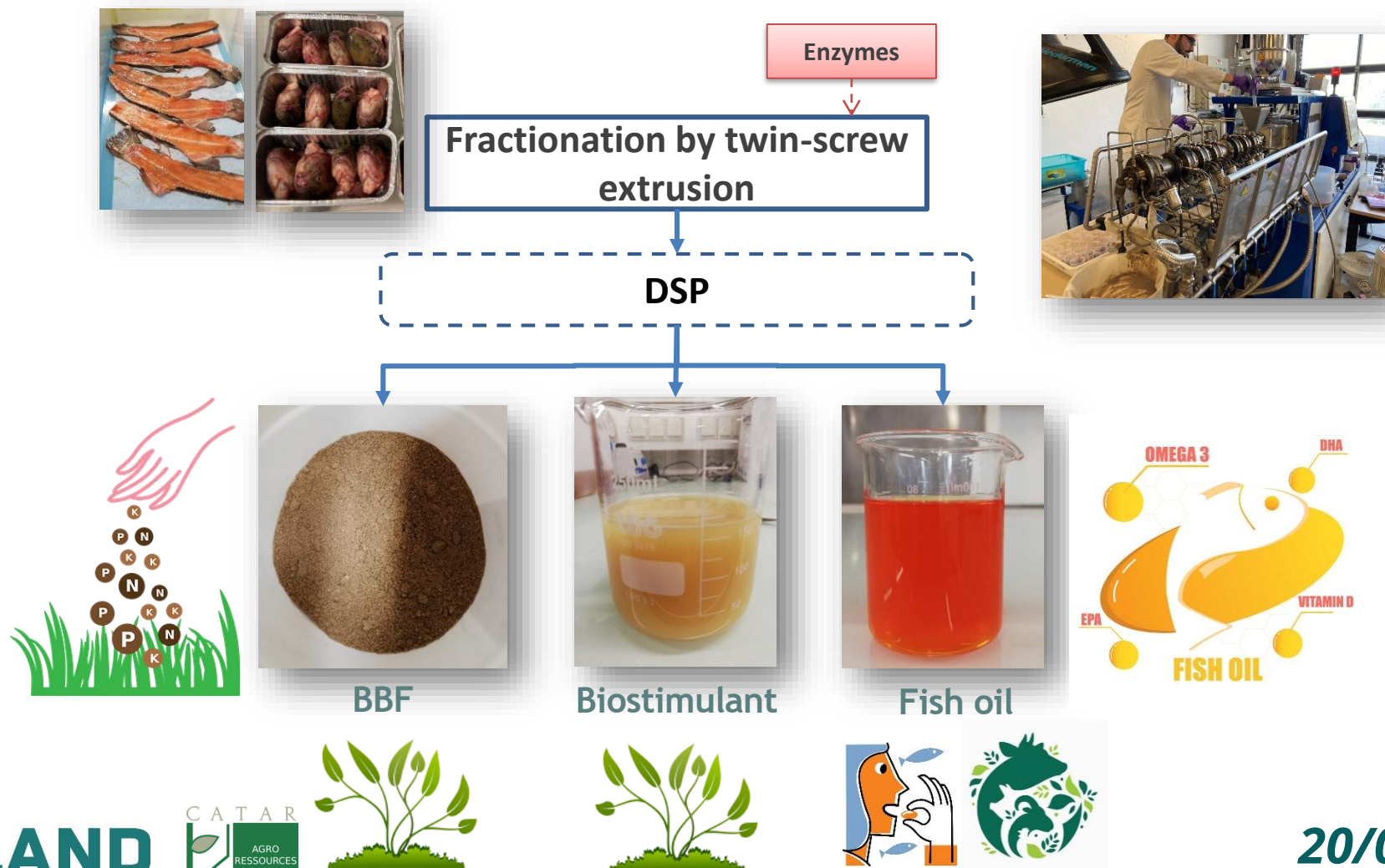
# SEA2LAND: The Atlantic case

## Identifying the advantages and drawbacks of the process

|                   |  |
|-------------------|--|
| <b>Advantages</b> | <ul style="list-style-type: none"><li>- Continuous process</li><li>- Intensification</li><li>- Industrial scale process</li><li>- Transformation of all categories of fish by-products</li><li>- Existing post-treatment</li><li>- Fish oil recovery</li></ul> |
| <b>Drawbacks</b>  | <ul style="list-style-type: none"><li>- No tolerance to impurities (plastic, stones, etc.): potential need for raw material pre-treatment</li><li>- When introducing enzymes, low degrees of protein hydrolysis</li><li>- High-cost investment</li></ul>       |



# SEA2LAND: The Atlantic case



20/09/2023



# SEALAND



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# Thank you!

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